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**RESEARCH ARTICLE** / ARAŞTIRMA MAKALESİ

# Projected Changes in High Temperatures in Coastal Tourism Destinations: A Case Study of the Turquoise Coast

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**Abstract**

The effects of climate change may manifest themselves in different ways, but when it comes to coastal tourism, extreme temperatures, which are the unavoidable consequences of climate change, come to the fore. The study examined the changes that extreme temperatures can make on major coastal tourism destinations by using such indices as hot summer days, tropical nights, combined hot days and tropical nights, and days with dangerous apparent temperature (> 40.6 °C). Under the RCP4.5 and RCP8.5 scenarios, increases in these indices are expected for Antalya, Aydın, Balıkesir, İzmir, and Muğla on the Turquoise Coast in the near (2021-2050) and distant (2071-2100) future. The projections based on both scenarios indicate that there might be a rise in the number of hot summer days, tropical nights, and days exceeding the critical human thermal comfort conditions on the Turquoise Coast. Expected increases may reach the highest values under the pessimistic scenario at the end of the century. The increase in these indices caused by rising temperatures may adversely affect the tourism sector due to changes in tourism demands, destinations, and seasonal shifts.

**Keywords:** Climate change, Summer tourism, Temperature extremes, Turquoise Coast

## I. INTRODUCTION

Today, we have started to feel the direct or indirect effects of climate change in every sector, and this situation primarily threatens the life and health of living and also impacts the built environment, for example, tourism infrastructure [1,2]. It is possible to determine the level of this threat by evaluating changes not only in average temperatures or precipitation but also in extreme events. Changes in the frequency, severity, impact area, and duration of extreme climate events resulting from climate change form the basis of physical and economic losses in many sectors [3]. Could the risks arising from changes in extreme climatic events pose a future comfort level threat for people trying to rest during their summer holidays? The answer to this question is quite significant in terms of sectoral adaptation of tourism to climate change. Understanding changes in climate parameters such as pressure, temperature, humidity, wind, and precipitation [4] constitutes the main aspect of climate change studies [5]. Climate change has adverse effects on natural, social, and economic sectors, including water resources, agriculture, ecosystems, forestry, health, insurance, and industry. The effects of climate change on the tourism sector have been investigated in recent years. The changes brought about by these effects can adversely affect tourism, a vital economic sector. To be more explicit, extreme climate events associated with temperature and precipitation may affect human health and comfort, and therefore the tourism sector since tourists prefer to travel to destinations where they will benefit from a feeling of well-being and comfort [6-13].

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Poor thermal comfort conditions can affect the quality of human life. Coastal tourism is the largest market segment of global tourism and is highly dependent on the thermal climate of a tourism destination. Therefore, the effects of climate change on the thermal comfort level of beach tourists are worth examining because comfort level is a key factor for tourists to choose a destination. Although climate change occurs at the global level, every economic industry can feel its impacts in different ways in various regions [14]. The effects of climate change on coasts are inevitable and are already damaging some areas whose economies depend heavily on coastal tourism [15]. The increase in temperature may become a significant threat to Mediterranean tourism and the economies of Mediterranean countries fueled by tourism revenues [16-19]. Over the past few decades, summer seasons with extremely hot temperatures have been increasing in various parts of the world [20-23]. This ongoing trend will affect the comfort level of people and, more importantly, lead to an increase in heat-related deaths [24-29].

Some indices have been developed to obtain general information about the climatic attractiveness of popular summer tourism destinations in terms of human comfort. The Tourism Climate Index (TCI), the first to examine human comfort levels in tourism-related activities, was designed in 1985 [30]. However, some researchers stated that TCI was based on subjective opinion and modified it. Beach Climate Index (BCI), developed in 2000, was one of them [31]. BCI was developed by modifying TCI by conducting surveys with more than 1600 beach users. However, it was developed only for beach use and cannot be used for other daytime activities. Also, conducting surveys only on northern European beaches makes them unsuitable for tourists vacationing in other regions because preferences change as well as tourist profiles. Climate Index for Tourism (CIT) was also designed by surveying tourists [32]. However, since all the participants examined in the study were university students, the narrow age distribution of the research sample group caused the index to lack cross-cultural information [32]. The Modified Climate Index for Tourism (MCIT) [33] uses hourly data rather than averages and assesses the suitability of a day's weather for tourist activities. Another index called Holiday Climate Index (HCI) was developed [34]. HCI does not rely on subjective opinions, as it uses the available literature on tourists' climate preferences from a series of surveys compiled over the previous decade to determine rating scales and weights for sub-indices. The development of these indices based on tourist preferences is one of their limitations because the preferences vary according to socio-demographic characteristics such as age, gender, the type of tourism environment and activity, and the climatic characteristics of the country from which the tourists come. For this reason, it is debated whether the use of questionnaires is reliable [35-37]. Since this study aimed to examine the changes brought by extreme temperatures in comfort level, other parameters such as precipitation and wind were ignored, and three biometeorological indices, hot summer days, tropical nights, and apparent temperature, were used. Hot summer days become much more stressful if nighttime temperatures do not provide cooling relief, and tropical nights make it harder for the body to cool down and recover from hot summer days. The combination of hot days and tropical nights is particularly dangerous for human comfort and health. On the other hand, high risk from heat stress is not related to temperature alone but is a function of the combined consequences of temperature and humidity [38,39]. Since high humidity tends to reduce the efficiency of the human body's cooling system by preventing sweat from evaporating, humidity levels can make extreme heat much more dangerous and unbearable [39]. The study examined apparent temperature, including the effect of humidity, along with hot summer days and tropical nights, to comprehensively interpret the behavior of heat stress in response to climate change. Such a combination may lead to serious health problems and be fatal, apart from adversely affecting the level of comfort. For this reason, knowing that such conditions will occur in a particular location can be helpful in planning for adapting to a changing climate and protecting vulnerable groups from heat. Moreover, despite a growing consensus on the future severity of extreme heat stress, geographic patterns and the magnitude of projected changes are poorly understood at the regional and local levels. Therefore, our study aims to shed light on the literature in terms of being a study at the regional level.

Extremely hot summer days are often accompanied by hot or tropical nights [40]. Tropical nights significantly impact sleep comfort and prevent people from recovering from heat during the day [41]. Densely populated areas along the eastern Mediterranean coast will be significantly affected by tropical nights [42]. The rise in hot summer days and tropical nights will lead to water and energy consumption and vector-borne infectious diseases that can cause significant economic losses in the tourism sector [41]. Recently, the apparent temperature, which reflects the combined effect of air temperature and relative humidity, thus providing a better physical sense of the current climatic conditions, has also attracted the attention of researchers [43]. Apparent temperature, based on a model of thermal balance of the human body [44], has been used in several studies of temperature-related discomfort, morbidity, and mortality [45-50]. Examining the changes in these indices can help us detect changing thresholds of human comfort level caused by extreme temperatures and take necessary precautions by measuring the response of human sensation to environmental conditions. These indices reflect changes in different aspects of climate, effectively

support scientific studies in detecting extreme climatic changes and facilitate comparison between extreme weather events in different regions [29,51,52].

The temperatures are already high in the provinces on the Turquoise Coast. This situation prompted us to investigate further the relationship between the number of hot summer days, tropical nights, and the number of days with dangerous apparent temperature, and the values which are above a certain threshold because proper measurement of human exposure to extreme temperatures is a necessary basis for studying the impacts of extreme temperatures on human comfort. It can also help determine the steps to be taken regarding the tourism sector. In this context, using climate change projections, the study aims to examine the changes brought by future extreme temperatures in the Turquoise Coast, which attracts millions of visitors as a coastal tourism destination in Türkiye and to draw attention to the effects of extreme temperatures on summer coastal tourism in terms of human comfort.

# II. MATERIALS AND METHOD

## 2.1. Domain

Since the areas where tourist movements are most intense are the sea and lake shores, coastal tourism is economically very important for Türkiye, which is a land surrounded by water on three sides and having various climatic characteristics. South and southwest of Türkiye are coastal tourism paradises with their uniquely beautiful beaches, sand, and sun opportunities, which have a long holiday period, and the climate that makes them suitable for coastal tourism [53]. Thanks to the warm weather and suitable climatic conditions in the summer months, they become popular sea-sand-sun oriented regions. The provinces studied in the study are located in the south-southwest and west of Türkiye (Figure 1).


**Figure 1.** Map of the study region

The tourism industry increases the population of a destination and causes seasonal population movements throughout the year. In most Mediterranean countries, population and population densities increase several times during the summer months [54]. Therefore, the population of the provinces that are the subject of the research increases several times during the tourism season. The approximate populations of the provinces examined as of 2021 are given in Table 1. The summer populations of these five metropolitans, each with a resident population exceeding 1 million, are experiencing further growth due to the influx of tourists. Tourism arrival, revenue and average spending information across Türkiye between 2004 and 2023 is also provided in Figure 2. Excluding the period of pandemics, it is evident that there is a positive trend in Türkiye's tourism revenue.

## 2.2. Materials

The tourism sector in Türkiye is mainly focused on sun-sea-sand tourism, with large facilities established in coastal areas. The sector is heavily dependent on "the Turquoise Coast," also known as "the Turkish Riviera," located along the Aegean and Mediterranean coasts in the southwestern part of Türkiye. The coastline is Türkiye's most popular tourist destination, and it is aptly named the Turquoise Coast with its turquoise-toned waters. It is famous for destinations such as İzmir, Balıkesir, Aydın, Muğla, and Antalya, and attracts more than 20 million tourists every year [55]. In addition, the region includes various hiking trails in the coastal and inland areas, along with the famous Lycian Way. It also offers a range of optional activities such as scuba diving, paragliding, and mountain biking.

**Table 1.** Populations and number of tourist arrivals of 5 provinces (thousand) [55]

| Province | Antalya | Aydın | Balıkesir | İzmir | Muğla |
|---|---|---|---|---|---|
| **Population** | 2,620 | 1,134 | 1,251 | 4,426 | 1,021 |
| **Tourist arrivals (2010-2019)** | 139,366 | 12,128 | 5,277 | 26,876 | 19,462 |

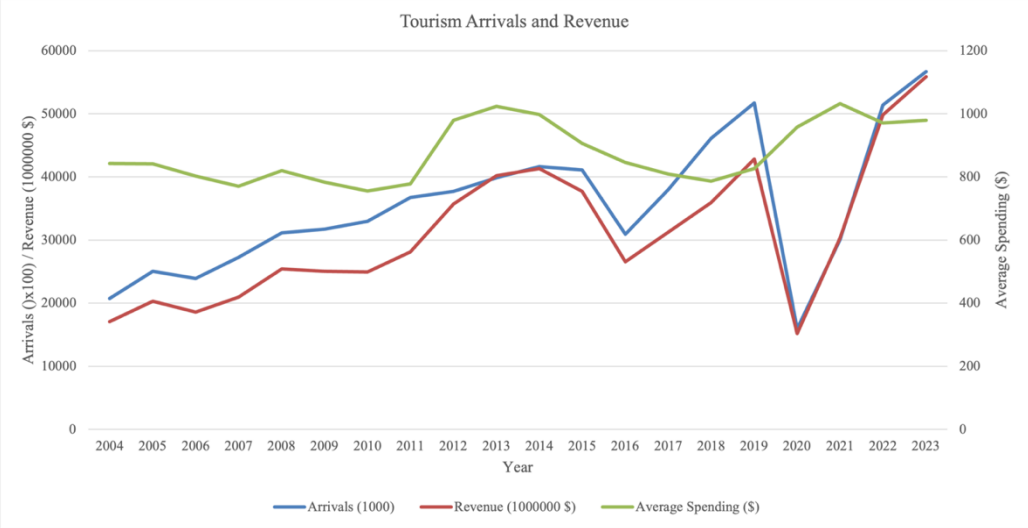


**Figure 2.** Tourism arrivals, revenue and average spending in Türkiye (2004-2023)

### 2.3. Methods

The study examined whether the advantage provided by the Mediterranean climate on the Aegean and Mediterranean coasts would turn into a disadvantage in the future. Three different indices were utilized: hot summer days, tropical nights, and apparent temperature (heat index). In calculating these indices, high resolution (10-km horizontal resolution) maximum temperature, minimum temperature, and relative humidity data were obtained using the regional climate model RegCM4.4, driven by the MPI-ESM-MR global climate model of the Max Planck Meteorological Institute in Germany.

The aforementioned indices calculated using these climate variables were compared to the past period of 1971-2000 under two different scenarios, RCP4.5 and RCP8.5, for the two future periods (2021-2050 and 2071-2100). The regional climate model RegCM4.4 was used to obtain the data. RegCM4.4 is a regional climate model widely used in climate-related studies [12,19,56-64]. It is a user-friendly model [65]. RegCM4.4 [65,66] dynamically downscaled the low-resolution outputs of the MPI-ESM-MR [67], under the RCP4.5 (optimistic) and RCP8.5 (pessimistic) scenarios [68] and provided high-resolution climate data (10 km horizontal resolution). Here, the acronym RCP stands for "Representative Concentration Pathway". In order to comprehend the potential future changes in climate, it is imperative to project the appropriate course of global climate action. Therefore, RCPs are designed to provide realistic future possibilities of human-induced forcing, covering a spectrum ranging from a scenario characterized by proactive reduction (RCP2.6), to two moderate scenarios (RCP4.5 and RCP6.0), and a progressively increasing emissions scenario (RCP8.5). Basically, RCP scenarios are classified based on their cumulative radiative forcing by the end of the century. RCP4.5 is a pathway that aims to stabilize the amount of radiative forcing at 4.5 W/m$^2$ after the year 2100 without exceeding this level. On the other hand, RCP8.5 corresponds to an increase in radiative forcing of 8.5 W/m$^2$ by the year 2100. When the two scenarios are compared in terms of atmospheric carbon dioxide concentration levels, the RCP4.5 scenario predicts that the $CO_2$ level will be approximately 487 ppm in the middle of the century and about 538 ppm by the end of the century. In contrast, the RCP8.5 scenario projects a significant increase to approximately 541 ppm by 2050 and a dramatic rise to about 936 ppm by 2100. The climate change community commonly classifies the RCP4.5 scenario as an optimistic scenario and the RCP8.5 scenario as a pessimistic scenario. Therefore, the study focused on two fundamental cases, one optimistic and one pessimistic. In brief, the study examined how increases in temperature extremes alter comfort levels for Türkiye's Aegean and Mediterranean coastal destinations under two different scenarios for the next three decades and the end of the last century.

### 2.3.1. Indices

*2.3.1.1. Hot summer days*

Hot summer days (HSD) is defined as the average number of days with a maximum temperature equal to or above 35 ℃ [28,69]. However, 37 ℃ threshold was used for Turquoise Coast in this study. As can be seen from some studies on hot summer days in the Mediterranean, this is the most appropriate threshold, as the studied area is already warm, and temperatures equal to or a little higher than 35 ℃ are quite common and are perceived as normal [9,12,20]. Hence, the selection of this threshold value is not arbitrary.

*2.3.1.2. Tropical nights*

Tropical nights (TN) index is defined as the average number of days with a minimum temperature above 20 ℃ [42,70]. However, as mentioned earlier, since the Turquoise Coast is already warm and these night-time temperatures (20 °C) are common during the summer months, 25 °C threshold was employed for TN based on the studies in the literature [71-73].

*2.3.1.3. Combined hot days and tropical nights*

The study also examines the frequency of days that experience both hot summer days and tropical nights simultaneously. The combined hot days and tropical nights (CHT) index is defined as the average number of days where the maximum temperature reaches 37 °C or more and the minimum temperature remains at 25 °C or higher throughout the day [8].

*2.3.1.4. Apparent temperature*

Apparent temperature (AT) is described as the temperature which considers the effect of both temperature and relative humidity, and it is usually referred to as heat index. Thermal comfort is a way to explore the impacts of climate change on comfort and health by quantifying the human sensation of environmental conditions. AT is also a measure of thermal comfort based on how the average person "feels" based on environmental conditions such as temperature and humidity [74]. AT was originally developed to measure thermal comfort [44] and has since been widely used in studies of the relationship between human comfort and health and extreme temperatures [8,47,48,75-78].

In the study, AT was used alongside other indices to represent the effect of exposure to typical temperatures commonly experienced in warmer months. Future changes in relative humidity may increase or stabilize the effects of extreme temperatures on human comfort or health [8]. To account for this effect, AT was calculated from the 3-hour resolution data and considered the daily maximum values of the apparent temperature. This calculation presents a combined measure of temperature and humidity stress [44]. A threshold value of 40.6 °C was used for AT in the study [8] because AT reaching levels of 40.6 °C signifies that heat-related "danger" may arise [8,79]. Therefore, in this study, apparent temperature above 40.6 °C was defined as dangerous. AT was used in this study because it was developed as a comfort index that accurately represents the human response to a wide temperature range [44]. The following formula to calculate AT was used [44]:

$$\mathrm{AT} = c_1 + c_2T + c_3T^2 + \mathrm{RH}(c_4 + c_5T + c_6T^2) + \mathrm{RH}^2(c_7 + c_8T + c_9T^2) \quad \textbf{(1)}$$

where $T$ is temperature, RH is relative humidity $c$ stands for coefficients. The coefficients are defined as follows [8]:

$c_1$ = -8.7847, $c_2$ = 1.6114, $c_3$ = -0.012308, $c_4$ = 2.3385, $c_5$ = -0.14612, $c_6$ = $2.2117*10^{-3}$, $c_7$ = -0.016425, $c_8$ = $7{,}2546*10^{-4}$, $c_9$ = $-3{,}582*10^{-6}$

## III. RESULTS

The study analyzed the changes in the number of hot summer days and tropical nights and days above the dangerous apparent temperature to address the signs of climate change on the Turquoise Coast. The sum of hot summer days and tropical nights were also evaluated together as a single index value.

### 3.1. Changes in the number of hot summer days

In the RCP4.5 scenario (Figure 3), an increase in the number of HSD in the near future and the distant future compared to the 1971-2000 reference period was detected. On the Turquoise Coast, there will be an increase in the number of HSD by 10-20 days in the near future, 2021-2050, and an increase up to 30 days in the distant future, namely 2070-2099 period. In the RCP8.5 scenario, the figure resembles the RCP4.5 scenario for the near future (2021-2050), and an increase of 10-20 days in the number of HSD in the near future is expected. However, in the distant future (2070-2099), an increase of 50-60 days is expected in the number of HSD on the Turquoise Coast compared to the 1971-2000 reference period (Figure 3).

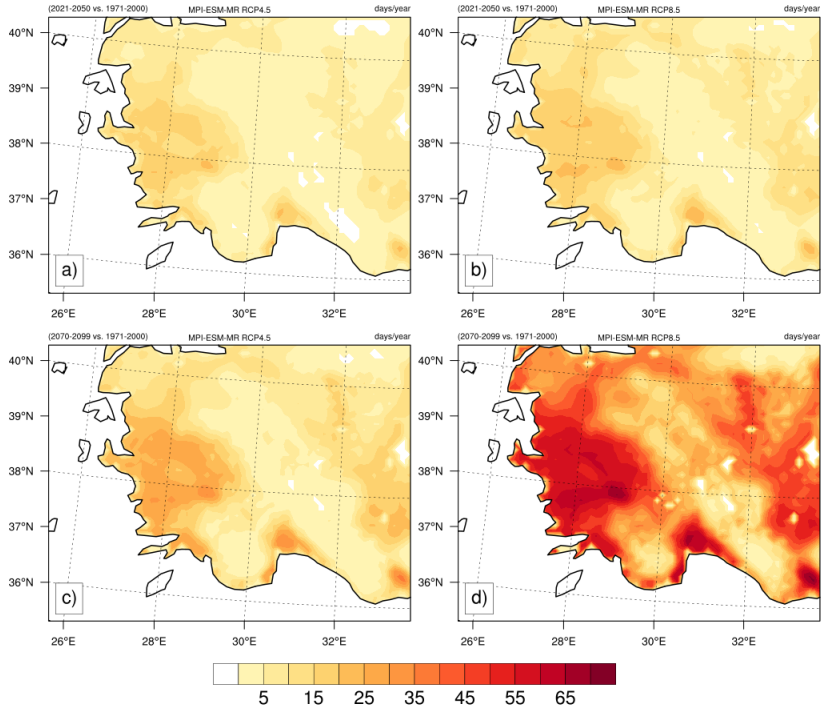


**Figure 3.** Changes in the number of HSD, a) RCP4.5 for 2021-2050; b) RCP8.5 for 2021-2050; c) RCP4.5 for 2070-2099; d) RCP8.5 for 2070-2099

When analyzed on a provincial basis, an increase in HSD is foreseen in all provinces for each scenario and period (Table 2). The lowest increase is expected in Antalya and the highest in Aydın. On the Turquoise Coast, an annual average increase of 4-15 days is expected in the near future for the RCP4.5 scenario, and an annual average increase of 8-26 days is anticipated in the distant future in the same scenario. For the RCP8.5 scenario, an average annual increase of 5-18 days is expected in the near future. For the RCP8.5 scenario, the most increase is expected in the distant future. The least increase is foreseen in Antalya (27 days) and the highest in Aydın (up to 56 days). In general, the highest annual average increase is projected in Aydın, followed by İzmir, Muğla, Balıkesir, and Antalya, respectively.

**Table 2.** Annual changes in the number of HSD on a provincial basis

| Provinces | RCP4.5 | | RCP8.5 | |
|---|---|---|---|---|
| | 2021-2050 | 2070-2099 | 2021-2050 | 2070-2099 |
| **Antalya** | 4.29 | 8.52 | 5.60 | 26.94 |
| **Aydın** | 15.11 | 25.20 | 17.56 | 56.01 |
| **Balıkesir** | 6.62 | 11.14 | 9.47 | 35.36 |
| **İzmir** | 12.05 | 19.95 | 14.52 | 47.94 |
| **Muğla** | 8.40 | 15.48 | 10.25 | 39.18 |

### 3.2. Changes in the number of tropical nights

As seen, the number of TN in both maps increases more in the seaside in the RCP4.5 and RCP8.5 scenarios (Figure 4) in the near (2021-2050) and distant (2070-2099) future periods. This is to be expected, as seas have a high heat capacity and daily minimum temperatures at night are higher than on land. Due to the increase in the number of TN, the highest increase is expected in coastal areas.

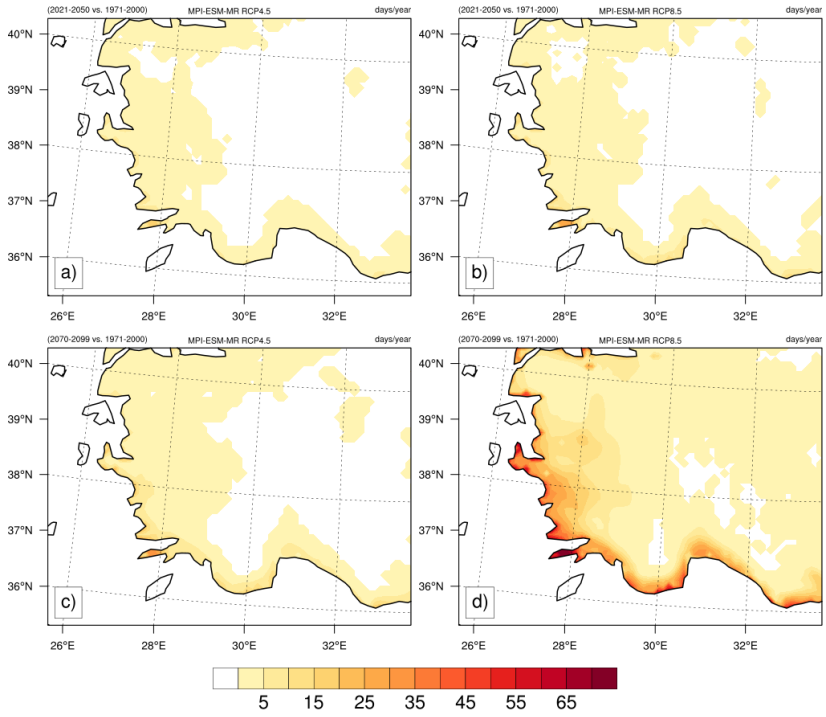


**Figure 4.** Changes in the number of TN, a) RCP4.5 for 2021-2050; b) RCP8.5 for 2021-2050; c) RCP4.5 for 2070-2099; d) RCP8.5 for 2070-2099

When analyzed on a provincial basis, it is seen that an increase in TN is predicted for all provinces for each scenario and period (Table 3). The lowest increase is foreseen in Balıkesir and the highest increase in Muğla. An annual average increase of up to 3 days is foreseen for the RCP4.5 scenario in the near future, and an annual average increase of 3-7 days is foreseen in the distant future in the same scenario.

For the RCP8.5 scenario, an annual average increase of up to 5 days is expected in the near future. For the RCP8.5 scenario, an increase of 6-25 days is predicted in the distant future. The lowest increase is foreseen in Balıkesir (6 days), and the highest increase is foreseen in Muğla (up to 25 days). In general, the highest annual average increase is expected in Muğla, followed by İzmir, Aydın, Antalya, and Balıkesir, respectively.

**Table 3.** Annual changes in the number of TN on a provincial basis

| Provinces | RCP4.5 | | RCP8.5 | |
|---|---|---|---|---|
| | 2021-2050 | 2070-2099 | 2021-2050 | 2070-2099 |
| **Antalya** | 1.21 | 3.78 | 2.83 | 15.38 |
| **Aydın** | 1.37 | 3.51 | 2.00 | 19.94 |
| **Balıkesir** | 0.24 | 0.75 | 0.45 | 6.11 |
| **İzmir** | 2.31 | 5.29 | 3.34 | 23.22 |
| **Muğla** | 3.08 | 6.88 | 4.90 | 25.30 |

### 3.3. Changes in the number of hot summer days and tropical nights

The spatial change in the number of CHT for both RCP4.5 and RCP8.5 scenarios compared to the reference period can be seen in Figure 5. It can be realized how extreme temperature indices create a change in coastal areas. For both scenarios, an increase in the number of CHT is expected in the coastal and inland areas in the near and distant future.

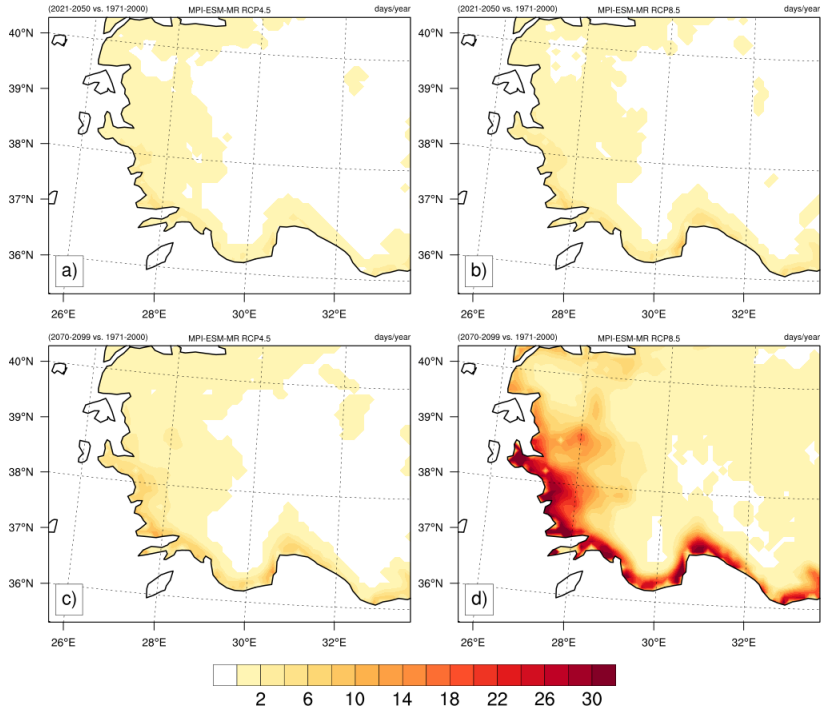


**Figure 5.** Changes in the number of CHT, a) RCP4.5 for 2021-2050; b) RCP8.5 for 2021-2050; c) RCP4.5 for 2070-2099; d) RCP8.5 for 2070-2099

On a provincial basis, an increase in the number of CHT is foreseen for all provinces for each scenario and period (Table 4). The lowest increase is expected in Balıkesir and the highest increase in Muğla. An annual average increase of 0.04-1.44 days is predicted for the RCP4.5 scenario in the near future and 0.28-3.45 days in the distant future for the same scenario. Under RCP8.5, an annual average increase of 0.12-1.90 days is expected in the near future and 3.94-17.11 days in the distant future. According to the RCP8.5 scenario, Balıkesir is expected to experience the lowest increase (3.94 days), while Aydın is projected to have the highest increase (17.11 days) in the distant future. Overall, Muğla is projected to have the highest annual average increase across all periods and scenarios.

**Table 4.** Annual changes in the number of CHT on a provincial basis

| Provinces | RCP4.5 | | RCP8.5 | |
|---|---|---|---|---|
| | 2021-2050 | 2070-2099 | 2021-2050 | 2070-2099 |
| **Antalya** | 0.51 | 1.93 | 1.31 | 9.47 |
| **Aydın** | 0.77 | 2.41 | 1.09 | 17.11 |
| **Balıkesir** | 0.04 | 0.28 | 0.12 | 3.94 |
| **İzmir** | 0.91 | 2.69 | 1.28 | 16.29 |
| **Muğla** | 1.44 | 3.45 | 1.90 | 16.17 |

### 3.4. Changes in the number of days with dangerous apparent temperature

A slight increase is observed in the number of days with dangerous apparent temperature in the coastal areas in the RCP4.5 scenario compared to the reference period of 1971-2000. However, this increase is more pronounced in the RCP8.5 scenario since the number of days with dangerous apparent temperature increases in touristic coastal areas. It shows that the number of days above 40.6 °C, which represents the dangerous starting point of heat-related disturbances, has been increasing. Principally, the increase in the number of days for AT in the Aegean Region for the RCP8.5 scenario in the distant future is striking (Figure 6).

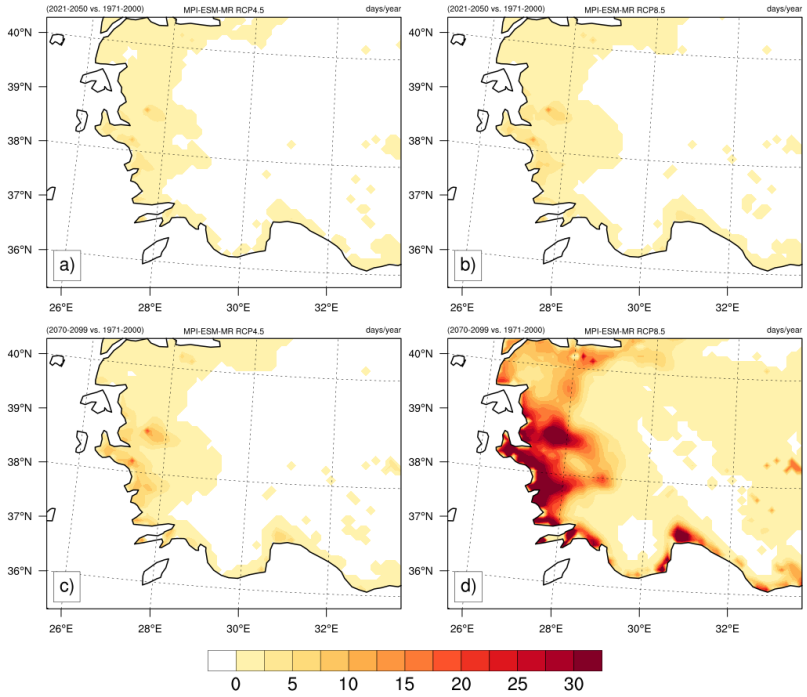


**Figure 6.** Changes in the number days for AT, a) RCP4.5 for 2021-2050; b) RCP8.5 for 2021-2050; c) RCP4.5 for 2070-2099; d) RCP8.5 for 2070-2099

An increase in the number of days for AT is foreseen for all provinces in each scenario and period (Table 5). The lowest increase is expected in Antalya and the highest increase in İzmir and Aydın. For the RCP4.5 in the near future, the annual average expected increase is at most 1 day. However, an annual average increase of up to 3 days is foreseen in the distant future.

Although the annual average expected to increase for the RCP8.5 scenario in the near future is still less, an increase of 4-20 days is expected for the RCP8.5 scenario in the distant future. The lowest increase is expected in Antalya (4 days), the highest increase in İzmir (19 days), and Aydın (20 days). In general, the highest annual average increase is expected to be in Aydın and İzmir, followed by Muğla, Balıkesir, and Antalya.

**Table 5.** Annual changes in the number of days for AT on a provincial basis

| Provinces | RCP4.5 | | RCP8.5 | |
|---|---|---|---|---|
| | 2021-2050 | 2070-2099 | 2021-2050 | 2070-2099 |
| **Antalya** | 0.12 | 0.49 | 0.24 | 4.75 |
| **Aydın** | 0.96 | 2.81 | 1.66 | 20.71 |
| **Balıkesir** | 0.07 | 0.65 | 0.43 | 7.27 |
| **İzmir** | 1.14 | 3.31 | 1.97 | 19.92 |
| **Muğla** | 0.52 | 1.46 | 0.71 | 11.33 |

## IV. DISCUSSION AND CONCLUSIONS

Tourism activities, which are vitally important for the countries on the Mediterranean coast and their economies, are vulnerable to climate change as they are sensitive to rising temperatures [80-82]. The potential comfort and health effects arising from predicted high temperatures in a changing climate should be taken into consideration.

According to the findings of the study, an increase in the number of hot summer days and tropical nights and the number of days with dangerous apparent temperature is expected in the future in the 5 provinces studied on the Turquoise Coast. Some studies about the regions close to Türkiye have found similar outcomes. For example, in a study on heatwaves in Europe, it is stated that an increase in hot days will be in the future

(2071-2100) [83]. There will be an increase in hot summer days for the 2070-2099 period in the future due to the increase in the frequency and intensity of droughts and extremely hot weather conditions [72]. Furthermore, an increase of 30 days in the number of hot summer days is expected as well as 2-4 weeks increase in the number of tropical nights for the period of 2031-2060 relative to 1961-1990 [84]. Using the 25 °C threshold for tropical nights, as in the case with this article, another study project an increase in the number of tropical nights in the Eastern Mediterranean and the Middle East for the end of the 21st century [73]. Evaluating the impact of extreme heat events in Europe, an increase in the number of tropical nights under 1.5 °C, 2 °C, and 3 °C global warming scenarios is expected [42]. Hot summer days and tropical nights may even lead to an increase in death rates. For example, in the period towards the end of the severe heatwave that hit France in the summer of 2003, deaths were mainly due to the extremely high value of tropical nights [85]. A series of high-resolution regional climate simulations was analyzed, and it was found that that summer heatwaves in Europe will become more frequent and severe this century, consistent with the trend observed in the past decades [8]. Therefore, the findings specific to Türkiye are consistent with the findings for Europe, the Mediterranean, and the Middle East regions.

An increase in the number of days with dangerous apparent temperature, another index examined in this study, is also expected in the 5 provinces on the Turquoise Coast in the future. Considering that apparent temperature aims to describe the body's ability to cool itself through perspiration and evaporation, the increase in apparent temperature upsets this ability. Studying the apparent temperature during the hot summer months in the Portuguese cities of Lisbon and Oporto, it was found that increases in apparent temperatures increase the rates of heart diseases and even death [86]. Furthermore, examining the increase in the number of days with dangerous apparent temperature for the Iberian Peninsula and Mediterranean coasts, an increase in the number of days with dangerous apparent temperature for the future periods of 2021-2050 and 2071-2100 was projected [8]. This study also states that an increase in the number of days with dangerous apparent temperature will have adverse health effects.

Our study did not analyze the effects of the increase in the number of hot summer days and tropical nights and in the number of days with dangerous apparent temperature, but it reveals the possible effects of increases in these indices on human comfort and health. Stating that climate change not only increases the ambient temperature but also causes population movements, climate change has implications for travel and disease risk [13]. Tourists may be at risk of disease due to factors in their country of origin and destination. The tourist climate comfort has already deteriorated in coastal countries and on the coasts of Türkiye, and this situation has worsened with warmer hinterlands and nights [12].

Considering the importance of coastal tourism, adaptive measures should be taken due to the vulnerability of the relationship between climate change and coastal tourism. Destinations can preserve their natural coastal environments and become more resilient and attractive to tourists, provided they have flexibility and foresight. A study, which relates developments in the history of the tourism industry to climate change, states that the mistakes of the past should not be repeated, and lessons should be learned from them in adapting the industry to the effects of climate change [87]. The main adaptation strategies are increasing scientific and social awareness, establishing early warning systems, and developing emergency response and adaptation processes.

The natural resources and climate of a destination are crucial economic drivers of tourism. Therefore, any change in the environment or climate creates both opportunities and challenges for the tourism industry. Due to the tourism sector's vulnerability to climate change impacts, it is necessary to investigate and implement adaptation methods and policies for the sector's exposure to the effects of climate change. It is believed that adaptation is the best course of action to lessen the industry's sensitivity to climate change [82,88-90]. Although the tourism sector needs to adapt to climate change, it is not fully recognized in the literature [91]. When the potential consequences of climate change are recognized, concentrating on adaptation measures can be simpler and more effective. The research on tourism has begun this phase recently.

For those who are especially at risk from the effects of climate change, better surveillance and control measures are required. Education initiatives regarding the dangers of exposure to high temperatures are needed [89]. It is crucial to collaborate with other organizations and sectors to advance urban green infrastructure that is appropriate for Mediterranean Basin countries [92]. It is important to work not only with the tourism industry but also with other industries associated with it, especially the health sector, regarding the health, environment and ecological threats that rising temperatures can pose. For instance, one area that needs to be expanded initially is the capacity of the health system, which will need to serve a capacity above the typical population during the summer tourist season. Planned adaptation may be the best course of action in light of the hazards posed by climate change. The planned adaptation process, on the other hand, should include risk management planning, funding the adaptation process, prioritizing research

and development activities, training, and effective communication, as well as accepting responsibility for each stakeholder, from local residents to governmental organizations.

The natural and cultural environments, as well as other resources that are important to the tourism industry, must be safeguarded. Policies created through inclusive processes are required to achieve it. Most research on tourism industry adaptation and policies highlight attempts to diversify products or shift places as the adaptation responses that have been most successful. Taking into account Türkiye's tourism strategy, the Development Plans launched in 1963 included various regulations that addressed the industry. These are associated with spending much more on advertising and promotion, diversifying tourist-related activities, raising tourism income, enticing investments and creating infrastructure facilities, and education tourism staff. None of the reports before 2019, however, make any specific mention of climate change; instead, they concentrate on raising the accommodation capacity and travel-related services. In the eleventh and final development plan covering the 2019-2023 targets, climate change, food security and water management issues and the importance of adaptation were mentioned, but specific targets related to these issues were not included [93]. Environmental goals including attempting to stop the exploitation and pollution of natural resources and preserving the ecological balance should be incorporated into the tourism policy [94]. Therefore, the growth of tourism can be accomplished in a way that ensures the preservation of natural and cultural resources for both present and future uses. Unplanned tourism development can result in issues like the degradation and alteration of the physical environment, the destruction of historical and cultural resources, crowding and noise in the tourist area, pollution of the environment, and traffic issues. These issues arise during the busy tourist season in 5 provinces that were the subject of this study.

Countries such as Türkiye, which heavily rely on tourism revenue, may face the potential for substantial financial losses due to climate change if they fail to implement adequate measures to mitigate risks and adapt to the changing climate. Adaptation is an appropriate response to reduce the tourism industry's vulnerability to climate change. Adapting to climate change is an imperative need, but this need is not fully understood in the tourism sector. Focusing on adaptation strategies can be easier and more efficient when the potential impacts of climate change are known. Examining the effects of climate change on a system is important for studies that evaluate and understand vulnerabilities and related adaptation measures. It is recommended that future research focus on adaptation solutions based on impact studies such as this research.

In conclusion, flexible and participatory approaches should be used to incorporate climate change into sustainable tourism policies. Effective control systems are also needed to ensure the implementation of these integrated policies. Additionally, education on climate change and its impacts is essential for all stakeholders, including governments, the private sector, and the public. Moreover, economic incentives can be provided for the implementation of climate change adaptation measures, including both tax breaks and taxation for tourism industry.

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